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(54) **METHODS FOR ISOLATING CRYSTALLINE FORM I OF 5-AZACYTIDINE**

VERFAHREN ZUR ISOLIERUNG DER KRISTALLINEN FORM I VON 5-AZACYTIDIN

PROCEDES PERMETTANT D'ISOLER LA FORME I CRISTALLINE DE LA 5-AZACYTIDINE

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- **BEISLER J A ET AL: "Chemistry of antitumor triazine nucleosides. An improved synthesis of Dihydro-5-AZacytidine", JOURNAL OF CARBOHYDRATES. NUCLEOSIDES NUCLEOTIDES, MARCEL DEKKER, BASEL, CH, vol. 4, no. 5, 1 January 1977 (1977-01-01) , pages 281-299, XP009089416, ISSN: 0094-0585**

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Description

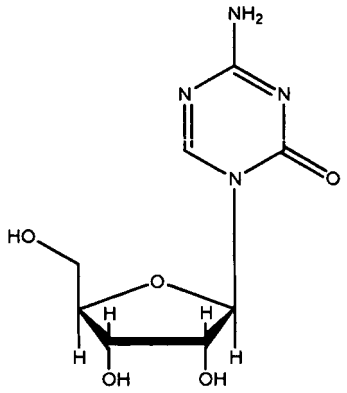
Field of the Invention

[0001] The invention relates to the isolation of crystalline polymorphic Form I of 5-azacytidine (also known as azacitidine and 4-amino-1-β-D-ribofuranosyl-S-triazin-2(1*H*-one). 5-azacytidine may be used in the treatment of disease, including the treatment of myelodysplastic syndromes (MDS).

Background of the Invention

[0002] Polymorphs exist as two or more crystalline phases that have different arrangements and/or different conformations of the molecule in a crystal lattice. When a solvent molecule(s) is contained within the crystal lattice the resulting crystal is called a pseudopolymorph, or solvate. If the solvent molecule(s) within the crystal structure is a water molecule, then the pseudopolymorph/solvate is called a hydrate. The polymorphic and pseudopolymorphic solids display different physical properties, including those due to packing, and various thermodynamic, spectroscopic, interfacial and mechanical properties (See H. Brittain, Polymorphism in Pharmaceutical Solids, Marcel Dekker, New York, NY, 1999, pp. 1-2). Polymorphic and pseudopolymorphic forms of the drug substance (also known as the "active pharmaceutical ingredient" (API)), as administered by itself or formulated as a drug product (also known as the final or finished dosage form, or as the pharmaceutical composition) are well known and may affect, for example, the solubility, stability, flowability, fractability, and compressibility of drug substances and the safety and efficacy of drug products, (see, *e.g.,* Knapman, K Modem Drug Discoveries, March 2000: 53).

[0003] 5-Azacytidine (also known as azacitidine and 4-amino-1-β-D-ribofuranosyl-S-triazin-2(1*H*)-one; Nation Service Center designation NSC-102816; CAS Registry Number 320-67-2) has undergone NCI-sponsored trials for the treatment of myelodysplastic syndromes (MDS). *See* Kornblith et al., J. Clin. Oncol. 20(10): 2441-2452 (2002) and Silverman et al., J. Clin. Oncol. 20(10): 2429-2440 (2002). 5-azacytidine may be defined as having a formula of $CgH_{12}N_4O_5$, a molecular weight of 244.20 and a structure of:



[0004] In the United States Patent Application Serial No. 10/390,578 (US Patent No. 6,887,855) entitled "Forms of 5-azacytidine," filed March 17, 2003, eight different polymorphic and pseudopolymorphic forms of 5-azacytidine (Forms I-VIII), in addition to an amorphous form, are described. Forms I-VIII each have characteristic X-Ray Powder Diffraction (XRPD) patterns and are easily distinguished from one another using XRPD.

[0005] US 3,817,980 discloses the synthesis of certain 5-azapyrimidine nucleosides by reacting a 1-O-acyl-1-O-alkyl- or a 1-halo-derivative of a blocked sugar residue with a silylated 5-azacytosine compound in the presence of a Lewis acid. The residue containing 5-azacytidine is crystallized from moist methanol.

[0006] M.W.Winkley and R.K. Robins, The Journal of Organic Chemistry (1970) 491-495, discloses the synthesis of 5-azacytidine by direct glycosylation of 1,3,5-triazines. The material is crystallized from aqueous ethanol.

[0007] US 3,891,623 describes the synthesis of cytidine and cytidine derivatives by reacting a 4-trialkylsilyloxyuridine derivative with ammonia or a primary or secondary amine, or with a salt of a primary or secondary amine in the presence of a tertiary amine.

[0008] US 6,723,728 discloses polymorphic forms of (-)- and (±)-cis-FTC (4-amino-5-fluoro-1-(2-(hydroxymethyl)-1,3-oxathiolan-5-yl)-2(1H)-pyrimidinone). The hydrated crystalline form of (±)-cis-FTC is obtained by dissolving (±)-cis-FTC in water and recrystallizing the FTC.

[0009] GB 1 227 691 A discloses isolating 1-glycosyl-5-azacytosine as a solid from certain reaction mixtures containing methanol.

[0010] A. Piscaia et ai., Nucleid Acid Chemistry (1978) 435-441 discloses isolating 5-azacytidine as a solid from a reaction mixture. The reaction was carried out in methanol. The solid was then crystallized from water-acetone.

[0011] A. Píscala et al., Collection of Czechoslovak Chemical Communications (1964) 2060-2069, discloses isolating 5-azacytidine as a solid from a reaction mixture. The reaction was carried out in methanol. The solid was then crystallized from water-methanol.

[0012] Beisler J.A. et al., Journal of Carbohydrates (1977) 281-299 discloses isolating 5-azacytidine as a solid from certain reaction mixtures. The reactions were carried out in methanol.

[0013] Beisler J.A. et al., Journal of Medicinal Chemistry (1978) 204-208 discloses crystallization of 5-azacytidine from ethanol-water.

[0014] In the United States Patent Application Serial No. 10/390,578 (US Patent No. 6,877,855) entitled "Forms of 5-azacytidine," filed March 17, it is demonstrated that this prior art method for the recrystallization of the crude synthesis product does not control for the polymorphic forms of 5-azacytidine. Specifically, the prior art recrystallization procedure produces either Form I substantially free of other forms, or a Form I/II mixed phase *i.e.* a solid material in which 5-azacytidine is present in a mixed phase of both polymorphic Form I and polymorphic Form II. Thus, the prior art procedures do not allow one to reliably target Form I as the single polymorphic form in the drug substance. The present invention provides methods that allow one to recrystallize 5-azacytidine as polymorphic Form I robustly and reproducibly.

Summary of the Invention

[0015] The present invention provides methods for robustly and reproducibly isolating 5-azacytidine as polymorphic Form I substantially free of other forms. The methods involve recrystallizing dissolved 5-azacytidine from DMSO/co-solvent mixture and then collecting the resultant crystals. Described are also pharmaceutical compositions comprising Form I of 5-azacytidine together with a pharmaceutically acceptable excipient, diluent, or carrier.

Detailed Description of the Preferred Embodiments

Polymorphic Form I of 5-azacytidine

[0016] Form I of 5-azacytidine is described in United States Patent Application Serial No. 10/390,578 (US Patent No. 6,877,855) entitled "Forms of 5-azacytidine," filed March 17, 2003. Table 1 provides the most prominent 2θ angles, d-spacing and relative intensities for Form I observed using X-Ray Powder Diffraction (XRPD) performed according the method of Example 4:

Table 1: 5-azacytidine Form I - the most prominent 2θ angles, d-spacing and relative intensities (Cu Kα radiation)

2θ Angle (°)	*d-spacing (Å)*	*Relative Intensity*
12.182	7.260	39.1
13.024	6.792	44.1
14.399	6.146	31.5
16.470	5.378	27.1
18.627	4.760	16.0
19.049	4.655	35.9
20.182	4.396	37.0
21.329	4.162	12.4
23.033	3.858	100.0
23.872	3.724	28.0
26.863	3.316	10.8
27.135	3.284	51.5
29.277	3.048	25.6
29.591	3.016	11.5
30.369	2.941	10.8
32.072	2.788	13.4

Isolation of Polymorphic Form I of 5-azacytidine by Recrystallization

[0017] Form I of 5-azacytidine may be reproducibly isolated substantially free of other forms by recrystallizing dissolved

5-azacytidine and collecting the resultant crystals. Specifically, 5-azacytidine is first dissolved completely in dimethylsulfoxide (DMSO).

[0018] The 5-azacytidine used to form the solution may be synthesized by any procedure known in the art; an exemplary synthesis scheme is provided in Example 1. Any polymorphic or pseudopolymorphic form(s) of 5-azacytidine, including mixed phases, may be used to form the solution. Amorphous 5-azacytidine may also be used to form the solution. It is preferred, but not required, that DMSO is preheated to an elevated temperature in order to ensure that the 5-azacytidine is dissolved completely. Dimethyl sulfoxide (DMSO) is most preferably preheated to a temperature in the range of about 40°C to about 90°C.

[0019] Following solvation of the 5-azacytidine in DMSO, at least one co-solvent selected from the group consisting of ethanol, 2-propanol (isopropyl alcohol), acetonitrile and methylethyl ketone, is added to the solution of 5-azacytidine. The use of mixtures of two or more of any of the aforementioned co-solvents is also included within the scope of the invention.

[0020] It is preferred, but not required, that the co-solvents are preheated before mixing with DMSO, preferably to a temperature below the temperature at which a substantial portion of the co-solvent would boil, most preferably to about 50°C. It is also preferred, but not required, that the co-solvent(s) is added gradually to DMSO.

[0021] Following mixing, DMSO/co-solvent(s) mixture is then equilibrated at different temperatures in order to promote either a slow recrystallization or a fast recrystallization of Form I of 5-azacytidine, as described below.

[0022] By slow recrystallization is meant that the co-solvent/DMSO solution is allowed to equilibrate at a temperature in the range from about 0°C to about 40°C, preferably in the range of about 15°C to about 30°C, and most preferably at about ambient temperature. Slow recrystallization of Form I of 5-azacytidine is performed using ethanol, isopropyl alcohol, methylethyl ketone or acetonitrile.

[0023] By fast recrystallization is meant that the co-solvent solution is allowed to equilibrate at a temperature of below 0°C, preferably below about -10°C, and most preferably at about -20°C. Fast recrystallization of Form I of 5-azacytidine is performed with 2-propanol (isopropyl alcohol) or acetonitrile as the co-solvent.

[0024] Examples of protocols for the recrystallization of Form I according to the methods described herein are provided in Examples 2 (slow recrystallization with DMSO as the primary solvent and ethanol, isopropyl alcohol, acetonitrile, or methylethyl ketone as the co-solvent) and 3 (fast recrystallization with DMSO as the primary solvent, and isopropyl alcohol or acetonitrile as the co-solvent) below.

[0025] Following recrystallization, the Form I of 5-azacytidine crystals may be isolated from the co-solvent mixture by any suitable method known in the art. Preferably, the Form I crystals are isolated using vacuum filtration through a suitable filter medium or by centrifugation.

[0026] Using the novel methods provided herein, it is possible for the first time to target Form I of 5-azacytidine as the drug substance reproducibly and robustly. In particular, isopropyl alcohol and acetonitrile reliably produce Form I independent of cooling rate (either slow recrystallization or fast recrystallization) and are preferred as the recrystallization co-solvents to recover Form I. Most preferably, Form I is isolated using isopropyl alcohol as the co-solvent since isopropyl alcohol carries a Class 3 risk classification (solvent of low toxic potential), whereas acetonitrile carries a Class 2 risk classification (solvent to be limited) per the International Conference of Harmonization's Guidelines for residual Solvents, July 1997. The use of the DMSO/isopropyl alcohol system allows Form I of 5-azacytidine to be reliably recovered for the first time from solvents of low toxic potential without requiring control over the rate of recrystallation. In the most preferred embodiment, Form I of 5-azacytidine may be recovered simply by dissolving 5-azacytidine in DMSO (preferably heated to a temperature in the range of about 40°C to about 90°C prior to the addition of 5-azacytidine), adding isopropyl alcohol, and allowing the resulting solvent mixture to equilibrate at about ambient temperature.

[0027] In some embodiments of the invention, Form I of 5-azacytidine may be recovered from a DMSO/co-solvent(s) mixture by "seeding" with a small amount of Form I of 5-azacytidine either prior to, or during, the addition of the co-solvent(s).

[0028] By allowing the isolation of a single polymorphic form, one skilled in the art will appreciate that the present invention allows for the first time the production of 5-azacytidine drug substance with uniform and consistent properties from batch to batch, which properties include but are not limited to solubility and dissolution rate. In turn, this allows one to provide 5-azacytidine drug product (see below) which also has uniform and consistent properties from batch to batch.

Pharmaceutical Formulations

[0029] For the most effective administration of drug substance of the present invention, it is preferred to prepare a pharmaceutical formulation (also known as the "drug product" or "pharmaceutical composition") preferably in unit dose form, comprising one or more of the 5-azacytidine polymorphs of the present invention and one or more pharmaceutically acceptable carrier, diluent, or excipient. Most preferably, Form I 5-azacytidine prepared according to the methods provided herein is used to prepare the pharmaceutical formulation.

[0030] Such pharmaceutical formulation may include a solid form of the present invention which is blended with at

least one pharmaceutically acceptable excipient, diluted by an excipient or enclosed within such a carrier that can be in the form of a capsule, sachet, tablet, buccal, lozenge, paper, or other container. When the excipient serves as a diluent, it may be a solid, semi-solid, or liquid material which acts as a vehicle, carrier, or medium for the 5-azacytidine polymorph (s). Thus, the formulations can be in the form of tablets, pills, powders, elixirs, suspensions, emulsions, solutions, syrups, capsules (such as, for example, soft and hard gelatin capsules), suppositories, sterile injectable solutions, and sterile packaged powders.

[0031] Examples of suitable excipients include starches, gum arabic, calcium silicate, microcrystalline cellulose, polyvinylpyrrolidone, cellulose, water, syrup, and methyl cellulose. The formulations can additionally include lubricating agents such as, for example, talc, magnesium stearate and mineral oil; wetting agents; emulsifying and suspending agents; preserving agents such as methyl- and propyl- hydroxybenzoates; sweetening agents; or flavoring agents. Polyols, buffers, and inert fillers may also be used. Examples of polyols include: mannitol, sorbitol, xylitol, sucrose, maltose, glucose, lactose, dextrose, and the like. Suitable buffers encompass phosphate, citrate, tartrate, succinate, and the like. Other inert fillers which may be used encompass those which are known in the art and are useful in the manufacture of various dosage forms. If desired, the solid pharmaceutical compositions may include other components such as bulling agents and/or granulating agents, and the like. The compositions described herein can be formulated so as to provide quick, sustained, controlled, or delayed release of the drug substance after administration to the patient by employing procedures well known in the art.

[0032] For reference only, the 5-azacytidine polymorph(s) may made into the form of dosage units for oral administration. The 5-azacytidine polymorph(s) may be mixed with a solid, pulverant carrier such as, for example, lactose, saccharose, sorbitol, mannitol, starch, amylopectin, cellulose derivatives or gelatin, as well as with an antifriction agent such as for example, magnesium stearate, calcium stearate, and polyethylene glycol waxes. The mixture is then pressed into tablets or filled into capsules. If coated tablets, capsules, or pulvules are desired, such tablets, capsules, or pulvules may be coated with a concentrated solution of sugar, which may contain gum arabic, gelatin, talc, titanium dioxide, or with a lacquer dissolved in the volatile organic solvent or mixture of solvents. To this coating, various dyes may be added in order to distinguish among tablets with different active compounds or with different amounts of the active compound present.

[0033] Soft gelatin capsules may be prepared in which capsules contain a mixture of the 5-azacytidine polymorph(s) and vegetable oil or non-aqueous, water miscible materials such as, for example, polyethylene glycol and the like. Hard gelatin capsules may contain granules or powder of the 5-azacytidine polymorph in combination with a solid, pulverulent carrier, such as, for example, lactose, saccharose, sorbitol, mannitol, potato starch, corn starch, amylopectin, cellulose derivatives, or gelatin.

[0034] Tablets for oral use are typically prepared in the following manner, although other techniques may be employed. The solid substances are gently ground or sieved to a desired particle size, and a binding agent is homogenized and suspended in a suitable solvent. The 5-azacytidine polymorph(s) and auxiliary agents are mixed with the binding agent solution. The resulting mixture is moistened to form a uniform suspension. The moistening typically causes the particles to aggregate slightly, and the resulting mass is gently pressed through a stainless steel sieve having a desired size. The layers of the mixture are then dried in controlled drying units for a pre-determined length of time to achieve a desired particle size and consistency. The granules of the dried mixture are gently sieved to remove any powder. To this mixture, disintegrating, anti-friction, and anti-adhesive agents are added. Finally, the mixture is pressed into tablets using a machine with the appropriate punches and dies to obtain the desired tablet size.

[0035] In the event that the above formulations are to be used for parenteral administration, such a formulation typically comprises sterile, aqueous and non-aqueous injection solutions comprising one or more 5-azacytidine polymorphs for which preparations are preferably isotonic with the blood of the intended recipient. These preparations may contain antioxidants, buffers, bacteriostats, and solute; which render the formulation isotonic with the blood of the intended recipient. Aqueous and non-aqueous suspensions may include suspending agents and thickening agents. The formulations may be present in unit-dose or multi-dose containers, for example, sealed ampules and vials. Extemporaneous injection solutions and suspensions may be prepared from sterile powders, granules, and tablets of the kind previously described.

[0036] Liquid preparations for oral administration are prepared in the form of solutions, syrups, or suspensions with the latter two forms containing, for example, 5-azacytidine polymorph(s), sugar, and a mixture of ethanol, water, glycerol, and propylene glycol. If desired, such liquid preparations contain coloring agents, flavoring agents, and saccharin. Thickening agents such as carboxymethylcellulose may also be used.

[0037] As such, the pharmaceutical formulations described herein are preferably prepared in a unit dosage form, each dosage unit containing from about 5 mg to about 200 mg, more usually about 100 mg of the 5-azacytidine polymorph (s). In liquid form, dosage unit contains from about 5 to about 200 mg, more usually about 100 mg of the 5-azacytidine polymorph(s). The term "unit dosage form" refers to physically discrete units suitable as unitary dosages for human subjects/patients or other mammals, each unit containing a predetermined quantity of the 5-azacytidine polymorph calculated to produce the desired therapeutic effect, in association with preferably, at least one pharmaceutically ac-

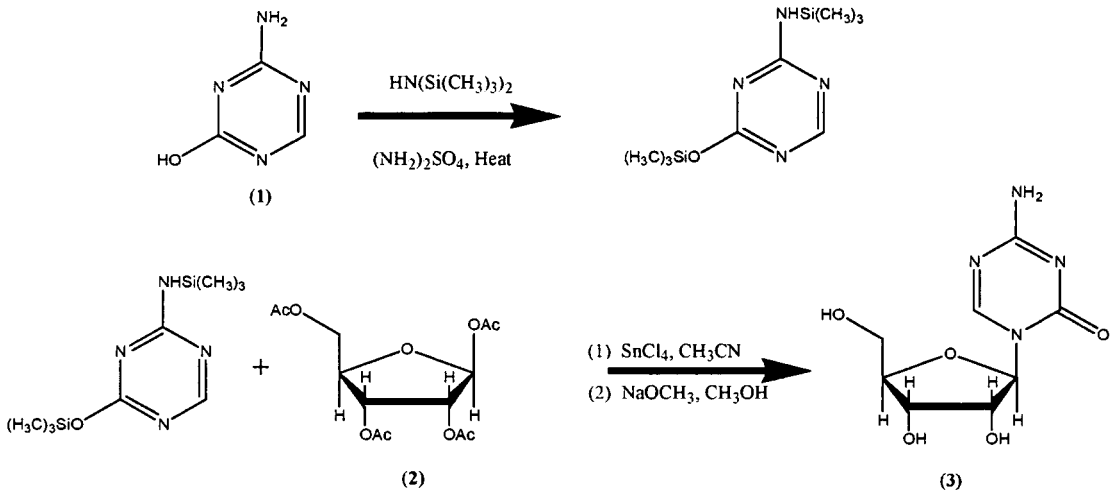
ceptable carrier, diluent, or excipient.

Examples

Example 1 (comparative)

Prior Art Procedure for Synthesis and Recrystallization of 5-azacytidine Drug Substance

[0038] 5-azacytidine may be synthesized using commercially available 5-azacytosine and 1,2,3,5-tetra-O-acetyl-β-D-ribofuranose (RTA) according to the following pathway:



[0039] The crude synthesis product is dissolved in DMSO (preheated to about 90°C), and then methanol is added to the DMSO solution. The co-solvent mixture is equilibrated at approximately -20°C to allow 5-azacytidine crystal formation. The product is collected by vacuum filtration and allowed to air dry.

Example 2

Form I of 5-azacytidine: Slow Recrystallization of 5-azacytidine from Co-Solvent Systems

[0040] Approximately 250 mg of 5-azacytidine was dissolved with approximately 5 ml of dimethyl sulfoxide (DMSO), preheated to approximately 90 °C, in separate 100-mL beakers. The solids were allowed to dissolve to a clear solution. Approximately 45 mL of ethanol, isopropyl alcohol, acetonitrile, or methyl ethyl ketone co-solvent, preheated to approximately 50 °C, was added to the solution and the resultant solution was mixed. The solution was covered and allowed to equilibrate at ambient conditions. The product was collected by vacuum filtration using a Buchner funnel.

Example 3

Form I of 5-azacytidine: Fast Recrystallization of 5-azacytidine from Co-Solvent Systems

[0041] Approximately 250 mg of 5-azacytidine was dissolved with approximately 5 mL of DMSO, preheated to approximately 90 °C, in separate 100-ml beakers. The solids were allowed to dissolve to a clear solution. Approximately 45 mL of isopropyl alcohol or acetonitrile co-solvent, preheated to approximately 50 °C, was added to the solution and the resultant solution was mixed. The solution was covered and placed in a freezer to equilibrate at approximately -20°C to allow crystal formation. Solutions were removed from the freezer after crystal formation. The product was collected by vacuum filtration using a Buchner funnel.

Example 4

X-Ray Powder Diffraction of Recrystallized 5-azacytidine

[0042] X-ray powder diffraction (XRPD) patterns for each sample were obtained on a Scintag XDS 2000 or a Scintag

X_2 θ/θ diffractometer operating with copper radiation at 45 kV and 40 mA using a Kevex Psi Peltier-cooled silicon detector or a Thermo ARL Peltier-cooled solid state detector. Source slits of 2 or 4 mm and detector slits of 0.5 or 0.3 mm were used for data collection. Recrystallized material was gently milled for approximately one minute using an agate mortar and pestle. Samples were placed in a stainless steel or silicon sample holder and leveled using a glass microscope slide. Powder diffraction patterns of the samples were obtained from 2 to 42° 2θ at 1°/minute. Calibration of the X_2 diffractometer is verified annually using a silicon powder standard.

[0043] XRPD performed according to this method revealed that the Form I of 5-azacytidine was isolated in Example 2 by slow recrystallization using either ethanol, isopropyl alcohol, acetonitrile, or methyl ethyl ketone as the co-solvent, and in Example 3 by fast recrystallization using isopropyl alcohol or acetonitrile as the co-solvent. The results indicate that Form I of 5-azacytidine may be reliably recovered from the DMSO/isopropyl alcohol and DMSO/acetonitrile solvent systems without control of the rate of recrystallization.

Claims

1. A method for isolating a crystalline form of 5-azacytidine comprising the steps of recrystallizing 5-azacytidine from a solvent mixture comprising dimethylsulfoxide and at least one co-solvent selected from the group consisting of ethanol, 2-propanol (isopropyl alcohol), acetonitrile and methylethyl ketone, by cooling said solvent mixture from a temperature selected to allow said 5-azacytidine to dissolve completely to ambient temperature; and
isolating the recrystallized 5-azacytidine.

2. The method according to claim 1, comprising the steps of:

   (i) preparing a solution comprising 5-azacytidine and dimethylsulfoxide;
   (ii) adding at least one co-solvent selected from the group consisting of ethanol, 2-propanol, acetonitrile, and methylethyl ketone to the 5-azacytidine solution and cooling the mixture to ambient temperature; and
   (iii) isolating recrystallized 5-azacytidine.

3. A method for isolating a crystalline form of 5-azacytidine comprising the steps of recrystallizing 5-azacytidine from a solvent mixture comprising dimethylsulfoxide and at least one co-solvent selected from the group consisting of 2-propanol (isopropyl alcohol) and acetonitrile, by cooling said solvent mixture from a temperature selected to allow said 5-azacytidine to dissolve completely to -20°C; and
isolating the recrystallized 5-azacytidine.

4. The method according to claim 3, comprising the steps of:

   (i) preparing a solution comprising 5-azacytidine and dimethylsulfoxide;
   (ii) adding at least one co-solvent selected from the group consisting of 2-propanol and acetonitrile to the 5-azacytidine solution and cooling the mixture to -20 °C; and
   (iii) isolating recrystallized 5-azacytidine.

5. The method according to any of claims 1-4, wherein said co-solvent is 2-propanol.

6. The method according to any of claims 1-4, wherein said co-solvent is acetonitrile.

7. The method according to any of claims 1 and 2, wherein said co-solvent is ethanol.

8. The method according to any of claims 1 and 2, wherein said co-solvent is methylethyl ketone.

9. The method according to any of claims 1 to 8, wherein the crystalline form of 5-azacytidine is **characterized by** peaks observed using X-Ray Powder Diffraction at 12.182, 13.024, 14.399, 16.470, 19.049, 20.182, 23.033, 23.872, 27.135, and 29.277 °2θ.

10. The method according to any of claims 1 to 8, wherein the crystalline form of 5-azacytidine is **characterized by** the following 2θ angles and d-spacing

2θ angle (°)	d-spacing (Å)
12.182	7.260
13.024	6.792
14.399	6.146
16.470	5.378
19.049	4.655
20.182	4.396
23.033	3.858
23.872	3.724
27.135	3.284
29.277	3.048

Patentansprüche

1. Verfahren zum Isolieren einer kristallinen Form von 5-Azacytidin, umfassend die Schritte des Umkristallisierens von 5-Azacytidin aus einem Lösungsmittelgemisch umfassend Dimethylsulfoxid und mindestens ein Co-Lösungsmittel, ausgewählt aus der Gruppe, die besteht aus Ethanol, 2-Propanol (Isopropylalkohol), Acetonitril und Methylethylketon, durch Abkühlen des Lösungsmittelgemischs von einer Temperatur, die ausgewählt ist, um das vollständige Lösen des 5-Azacytidins zu ermöglichen, auf Raumtemperatur; und
Isolieren des umkristallisierten 5-Azacytidins.

2. Verfahren nach Anspruch 1, umfassend die folgenden Schritte:

   (i) Herstellen einer Lösung umfassend 5-Azacytidin und Dimethylsulfoxid;
   (ii) Hinzufügen mindestens eines Co-Lösungsmittels, ausgewählt aus der Gruppe, die besteht aus Ethanol, 2-Propanol, Acetonitril und Methylethylketon zu der 5-Azacytidin-Lösung und Abkühlen des Gemischs auf Raumtemperatur; und
   (iii) Isolieren des umkristallisierten 5-Azacytidins.

3. Verfahren zum Isolieren einer kristallinen Form von 5-Azacytidin, umfassend die Schritte des Umkristallisierens von 5-Azacytidin aus einem Lösungsmittelgemisch umfassend Dimethylsulfoxid und mindestens ein Co-Lösungsmittel, ausgewählt aus der Gruppe, die besteht aus 2-Propanol (Isopropylalkohol) und Acetonitril, durch Abkühlen des Lösungsmittelgemischs von einer Temperatur, die ausgewählt ist, um das vollständige Lösen des 5-Azacytidins zu ermöglichen, auf -20°C; und
Isolieren des umkristallisierten 5-Azacytidins.

4. Verfahren nach Anspruch 3, umfassend die folgenden Schritte:

   (i) Herstellen einer Lösung umfassend 5-Azacytidin und Dimethylsulfoxid;
   (ii) Hinzufügen mindestens eines Co-Lösungsmittels, ausgewählt aus der Gruppe, die besteht aus 2-Propanol und Acetonitril zu der 5-Azacytidin-Lösung und Abkühlen des Gemischs auf -20°C; und
   (iii) Isolieren des umkristallisierten 5-Azacytidins.

5. Verfahren nach einem der Ansprüche 1-4, wobei das Co-Lösungsmittel 2-Propanol ist.

6. Verfahren nach einem der Ansprüche 1-4, wobei das Co-Lösungsmittel Acetonitril ist.

7. Verfahren nach einem der Ansprüche 1 und 2, wobei das Co-Lösungsmittel Ethanol ist.

8. Verfahren nach einem der Ansprüche 1 und 2, wobei das Co-Lösungsmittel Methylethylketon ist.

9. Verfahren nach einem der Ansprüche 1-8, wobei die kristalline Form von 5-Azacytidin durch Peaks bei 12.182, 13.024, 14.399, 16.470, 19.049, 20.182, 23.033, 23.872, 27.135, und 29.277 °2θ gekennzeichnet ist, festgestellt mittels Röntgenpulverdiffraktometrie.

10. Verfahren nach einem der Ansprüche 1-8, wobei die kristalline Form von 5-Azacytidin durch die folgenden 20-Winkel und d-spacings gekennzeichnet ist:

2θ-Winkel (°)	d-spacing (Å)
12.182	7.260
13.024	6.792
14.399	6.146
16.470	5.378
19.049	4.655
20.182	4.396
23.033	3.858
23.872	3.724
27.135	3.284
29.277	3.048

Revendications

1. Procédé d'isolement d'une forme cristalline de la 5-azacytidine, comprenant les étapes de recristallisation de la 5-azacytidine à partir d'un mélange de solvants comprenant du diméthylsulfoxyde et au moins un co-solvant choisi dans le groupe constitué par l'éthanol, le 2-propanol (alcool isopropylique), l'acétonitrile et la méthyléthylcétone, par refroidissement dudit mélange de solvants à partir d'une température choisie pour permettre à ladite 5-azacytidine de se dissoudre complètement à la température ambiante ; et
isolement de la 5-azacytidine recristallisée.

2. Procédé selon la revendication 1, comprenant les étapes de :

(i) préparation d'une solution comprenant de la 5-azacytidine et du diméthylsulfoxyde ;
(ii) ajout d'au moins un co-solvant choisi dans le groupe constitué par l'éthanol, le 2-propanol, l'acétonitrile, et la méthyléthylcétone à la solution de 5-azacytidine et refroidissement du mélange à la température ambiante ; et
(iii) isolement de la 5-azacytidine recristallisée.

3. Procédé d'isolement d'une forme cristalline de la 5-azacytidine, comprenant les étapes de recristallisation de la 5-azacytidine à partir d'un mélange de solvants comprenant du diméthylsulfoxyde et au moins un co-solvant choisi dans le groupe constitué par le 2-propanol (alcool isopropylique) et l'acétonitrile, par refroidissement dudit mélange de solvants à partir d'une température choisie pour permettre à ladite 5-azacytidine de se dissoudre complètement à -20°C ; et
isolement de la 5-azacytidine recristallisée.

4. Procédé selon la revendication 3, comprenant les étapes de :

(i) préparation d'une solution comprenant de la 5-azacytidine et du diméthylsulfoxyde ;
(ii) ajout d'au moins un co-solvant choisi dans le groupe constitué par le 2-propanol et l'acétonitrile à la solution de 5-azacytidine et refroidissement du mélange à -20°C ; et
(iii) isolement de la 5-azacytidine recristallisée.

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel ledit co-solvant est le 2-propanol.

6. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel ledit co-solvant est l'acétonitrile.

7. Procédé selon l'une quelconque des revendications 1 et 2, dans lequel ledit co-solvant est l'éthanol.

8. Procédé selon l'une quelconque des revendications 1 et 2, dans lequel ledit co-solvant est la méthyléthylcétone.

9. Procédé selon l'une quelconque des revendications 1 à 8, dans lequel la forme cristalline de la 5-azacytidine est **caractérisée par** les pics observés en utilisant une diffraction des rayons X sur poudre à 12,182, 13,024, 14,399, 16,470, 19,049, 20,182, 23,033, 23,872, 27,135, et 29,277°2θ.

10. Procédé selon l'une quelconque des revendications 1 à 8, dans lequel la forme cristalline de la 5-azacytidine est **caractérisée par** les angles 2θ et l'espacement d suivants

Angle 2θ (°)	Espacement d (Å)
12,182	7,260
13,024	6,792
14,399	6,146
16,470	5,378
19,049	4,655
20,182	4,396
23,033	3,858
23,872	3,724
27,135	3,284
29,277	3,048

REFERENCES CITED IN THE DESCRIPTION

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